

THE EFFECT OF **FRESHPAX** OXYGEN-ABSORBING
PACKETS ON THE SHELF-LIFE OF FOODS

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SUMMARY

The effect of **FreshPax** oxygen absorbing packets (product of Multisorb Technologies, Inc.) on the shelf life of perishable foods was investigated. Fresh baked bread and mozzarella cheese were each inoculated with mold spores and packaged with or without the packets in moderate and high barrier flexible pouches. Pouches were stored at 23°C and mold counts determined weekly. The packets substantially inhibited the development of mold in both moderate and high barrier pouches. Differences in mold counts between the test and control samples were as great as 1,000 fold. Bread without the packets had visible mold growth within 7 days, however, mold was not visible at the termination of the study (8 weeks) when a packet was included in the sealed pouch. The findings were similar for cheese. The packets were effective in reducing the oxidative formation of n-hexanal (an indicator of off-flavor development) in both sunflower seeds and corn chips. Sensory panel analyses of fresh peanuts showed that the packets inhibited the formation of undesirable rancid odors during accelerated storage tests.

These experiments were designed to be an extreme test of the **FreshPax** packets in that large volume ratios of headspace to product (>10 fold) were used and the products were stored at abusive temperatures. The resulting data indicated that **FreshPax** are effective at extending the shelf life of foods stored at abusive temperatures, even in moderate barrier packages with a large head space.

INTRODUCTION

The shelf life of packaged foods is dependent on storage conditions (temperature, relative humidity, and oxygen concentration), product composition (A_w , pH, lipid composition, etc.) and package properties (volume, headspace composition, barrier properties)⁽¹⁾. While reformulation can increase product stability intrinsically, it is difficult to do so without changing the character of the food or using additives, which have a negative consumer image. Much of the research in extending the shelf life, safety, and quality of foods has shifted from manipulating the product to controlling the packaging system^(2,3). Often the emphasis lies in controlling the atmosphere (particularly oxygen) inside the package, since oxygen is a major factor in food deterioration. Oxygen is necessary for the growth of most spoilage and many pathogenic organisms, including molds^(4,5), which are responsible for much food spoilage⁽⁶⁾. Oxygen is also responsible for the oxidation of polyunsaturated fats and oils, vitamins, and pigments⁽⁶⁾, causing a decrease in flavor quality and nutritional value of products.

There are many ways in which the effects of oxygen have been counteracted. One of them is the use of additives, such as antimicrobial agents or antioxidants^(6,7), but as discussed above, additives can be undesirable. Modified atmosphere packaging (MAP) has been effectively used to prolong the shelf-life of fresh produce, fish, and meats^(8,9) among others.

Oxygen absorbers are materials that absorb oxygen from the environment through a chemical or enzymatic reaction and so

do not require the atmosphere in the package to be altered prior to closure. Oxygen scavengers can be used to extend shelf-life by eliminating oxygen without being a part of the food itself (i.e., they are not food additives). Oxygen absorbers have been shown to prevent autoxidation of polyunsaturated fatty acids in fish⁽¹⁰⁾, and avoid molding of bread⁽¹¹⁾. They are also used to improve the aroma of packaged coffee.

The objectives of the present study were to evaluate the effectiveness of **FreshPax** oxygen absorbers in protecting oxygen-sensitive food products during accelerated storage tests. Specifically, the ability to inhibit molds in bread and cheese and the development of rancid odors in high fat snack foods due to oxidation were tested.

MATERIALS AND METHODS

Food Products: Five foods which deteriorate due to the presence of oxygen were obtained from local markets in fresh condition:

1. Sliced preservative-free white bread obtained from a local bakery (mold growth).
2. Shredded low-moisture (part skim) mozzarella cheese (mold growth).
3. Unsalted corn tortilla chips (measurement of oxidation products).
4. Roasted fresh sunflower seeds (measurement of oxidation products).
5. Fresh roasted unsalted peanuts (sensory analyses).

Packaging system: Two types of flexible packaging were used for all tests. Foods were packaged in 6" x 7" heat-sealed pouches made of either a moderate barrier film (0.8 mil Nylon, 1.2 mil EVA, 1.2 mil Surlyn; GTR 0₂, 32 cc/M²/day) or very high barrier (0.75 mil polyester, .75 mil foil, 1 mil PP; GTR too low to measure). Foods were sealed either with (test) or without (control) **FreshPax** packets (product of Multisorb Technologies, Inc., 325 Harlem Road, Buffalo, NY 14224-1893).

Mold inoculations—Mold cultures were isolated from household bread and cheese by sampling into acidified PDA^(12,13) and observing and transferring cultures until pure cultures of *Aspergillus* spp. and *Penicillium* spp.⁽¹⁴⁾ were obtained. The pure colonies were kept in nutrient broth until used. Samples were inoculated by atomizing a 0.1 ml of the mold suspension in phosphate buffer onto 11 g of sample on a plate⁽¹³⁾. The inoculum level was estimated by spraying an equal amount onto PDA and incubating for 5 days. The pouches were stored upright at 23°C. Duplicate samples were taken weekly and mold counts determined^(17,18) on acidified PDA agar⁽¹²⁾. Results were reported as colony forming units per g (CFU/g) food.

Oxidation Products—Ten g of sunflower seeds or corn chips were packaged with or without oxygen absorber packets. Samples were stored at 65°C to accelerate the rate of autoxidation⁽⁶⁾. Oxidative rancidity was determined by direct sampling headspace gas chromatography using n-hexanal as a measure of oxidative rancidity^(17,18,19,20). After storage, samples were ground in the sealed pouch, and two

3.00 g samples weighed into 30 ml vials with screw caps and rubber septa. The samples and a gas-tight syringe were placed in an air oven at 90°C for 1 hour to equilibrate⁽²¹⁾ and 1 ml of headspace injected into the GC. Operating conditions were: Hewlett Packard Gas Chromatograph Model 5790 with FID (Flame Ionization Detector). Glass capillary column 25 m x 0.2 mm Carbowax 20M. Carrier N₂ 8.5 ml/min, isothermal at 100°C, injector and detector 200°C. The amount of n-hexanal formed was quantified against external standards.

Sensory Methods—Twenty g samples of peanuts were packaged in both films and stored at 50°C. Flavor scores were assigned by a sensory panel consisting of 40 subjects with experience in sensory methods but not trained in peanut flavor evaluation. Tests were conducted in a sensory room equipped with adequate lighting and individual booths. Panelists were presented with two pairs of 5 g samples in small cups. Each contained a randomly coded treatment and control sample. The panelists were asked to circle which sample they considered the fresher of the two based on odor and taste. This test was repeated weekly until a statistically significant preference was found⁽²²⁾. Once a significant difference was found, panelists were asked to rate different sensory attributes and preferences on a hedonic scale⁽²³⁾. The descriptive terms were derived from a lexicon developed to describe peanut flavor⁽²⁴⁾. Results were analyzed by analysis of variance⁽²²⁾.

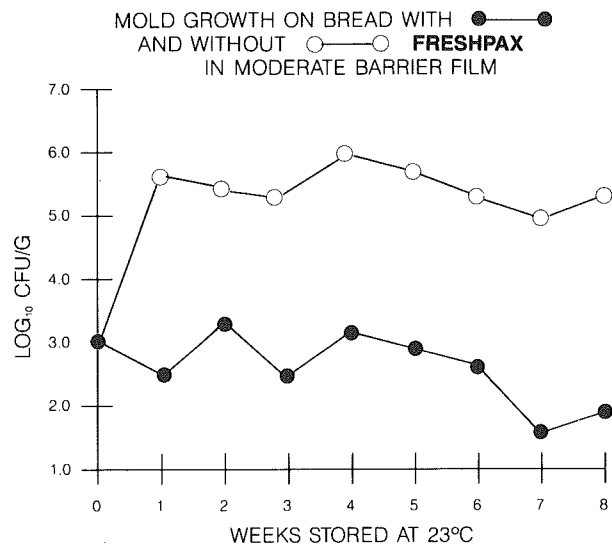


Figure 1. Growth curve for molds inoculated onto bread and stored (23°C) in moderate barrier pouches with (solid circles) or without (open circles) **FreshPax**.

RESULTS AND DISCUSSION

The oxygen scavengers significantly inhibited the growth of molds in both the high and moderate barrier packages. In bread, the mold count rose sharply during the first week in both moderate and high barrier packages without oxygen absorbers, while in the packages with **FreshPax** the counts decreased in both films (Figures 1 & 2). The rapid absorption of oxygen by the packets likely prevented molds from reaching their exponential growth phase during the first 7 days of storage. The oxygen in the headspace of the control samples was sufficient to support rapid growth. The oxygen transmission rate in the moderate-barrier film was high enough to allow slow growth in pouches not containing the packets during the remainder of the study. The **FreshPax** were effective at controlling the permeated oxygen in the moderate barrier samples resulting in no appreciable growth. Samples packed with the **FreshPax** had no visible mold or odor during the entire study, while the controls exhibited visible mold after 9 days of storage and became grossly contaminated after 15 days. In the high barrier film, both control and treatment populations decreased after the first three weeks due to lack of oxygen ingress through this material. These data suggest that the less costly lower barrier film could be substituted for the high barrier film if an oxygen absorber pack were included in the package.

Results (Figures 3 & 4) with inoculated cheese were similar to those in bread except that mold counts in both test and control samples in the high barrier film decreased after the fourth week. However, the pouches containing **FreshPax**



Figure 2. Growth curve for molds inoculated onto bread and stored (23°C) in high barrier pouches with (solid circles) or without (open circles) **FreshPax**.

consistently had lower counts than those without the packets. It is likely that the reduction in oxygen due to rapid microbial growth and the lack of permeation in the high barrier package was responsible for the loss of mold viability.

These data show that oxygen absorbers successfully control mold growth in products that are highly susceptible to spoilage by mold.

Oxidation—n-Hexanal, as well as other carbonyl compounds, are products of lipid oxidation and are responsible for off-odors associated with rancidity. The presence of these compounds in foods is undesirable and has been positively correlated with rancidity⁽⁶⁾. n-Hexanal is the major product of linoleic acid autoxidation, and its determination by headspace GC is sensitive and accurate⁽²¹⁾.

Figure 5 shows typical chromatograms obtained from sunflower seeds stored with and without the **FreshPax**. After 10 days at 65°C, the n-hexanal content as well as total volatiles, increased in the control packages (Figure 5 and Table 1). In most samples, **FreshPax** reduced the n-hexanal content to approximately one-half that of packages not containing the absorber packets. In corn chips, the levels of n-hexanal increased without **FreshPax**, but were too low to accurately quantify. In moderate barrier film, n-hexanal levels were greater in controls than in samples with **FreshPax**.

The reduction of headspace oxygen retards lipid autoxidation, and therefore retards the development of oxidation-derived off-odors. However, since autoxidation is a free-radical reaction, very small amounts of oxygen can still be enough to catalyze oxidation especially if oxygen is activated to the singlet state⁽⁶⁾. These data show that the **FreshPax** reduced lipid oxidation, especially in moderate barrier packaging. While not tested in these experiments, it is well documented that the formation of n-hexanal correlates with sensory detection of off-odors⁽¹⁹⁾. Reduction of n-hexanal in these samples would likely result in an increased flavor acceptability and longer shelf life.

Sensory evaluation—Tables 2 and 3 summarize the sensory panel results. In low barrier film, the panelist found after only two weeks that the samples containing the **FreshPax** were significantly ($\alpha=.05$) “fresher tasting” than those not containing the packets (controls). The second phase of the study indicated that this perception was due to the development of undesirable rancid odors (Table 3). This coincides with the predicted results and confirms the gas chromatography data since the presence of the oxygen absorber would prevent or greatly reduce the development of oxidative rancidity.

After 3 weeks in the high barrier film, the panelists found the controls (no packets) “fresher tasting.” When presented with the second questionnaire, the panelists indicated that the samples packaged in high barrier film with the oxygen scavenger had almost no aroma and many panelists indicated that the samples were “too dry.” This may have resulted from absorption water by the **FreshPax** and a change in peanut texture.

The **FreshPax** absorbed lipids from foods by wicking, giving the packets dark appearance. This did not affect the performance of the packets. The packets are almost bite-size, and although very obvious in sliced bread, there is the risk that a consumer could ingest them.

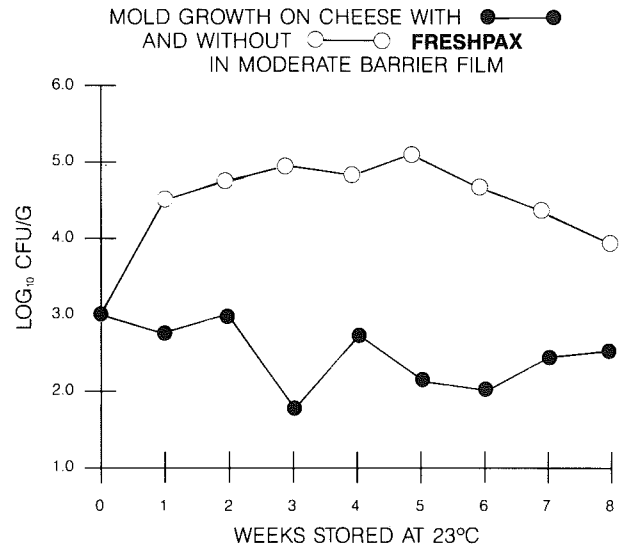


Figure 3. Growth curve for molds inoculated onto cheese and stored (23°C) in moderate barrier pouches with (solid circles) or without (open circles) **FreshPax**.

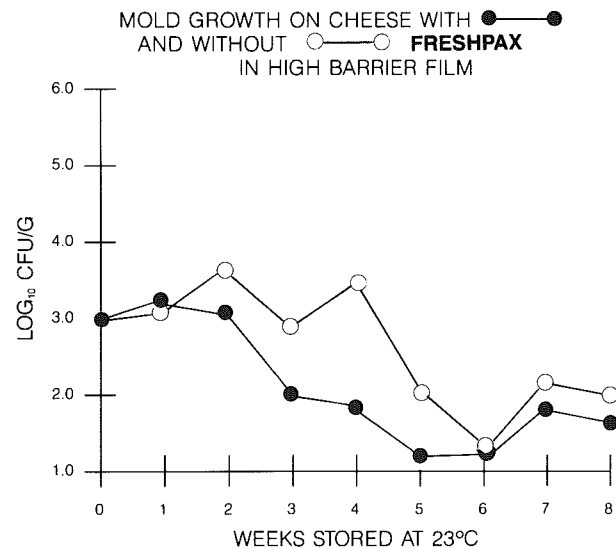


Figure 4. Growth curve for molds inoculated onto cheese and stored (23°C) in high barrier pouches with (solid circles) or without (open circles) **FreshPax**.

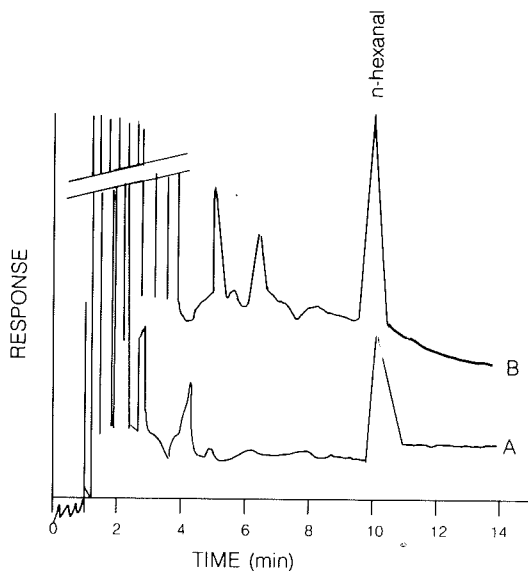


Figure 5. Chromatograms of the headspace from sunflower seeds stored (65°C) with (A) or without (B) **FreshPax**. The large peak at a retention time of approximately 11 min. had the same retention time as n-hexanal.

CONCLUSIONS

The use of **FreshPax** oxygen scavenger packets resulted in a decrease in mold and mold spoilage of commercial cheese and bread, and considerable extension of shelf-life. They also reduced the formation of n-hexanal and other volatile compounds in high-fat snack foods susceptible to oxidative rancidity of polyunsaturated fats and oils. The packets improved the sensory characteristics of peanuts over time by preventing the development of strong off-odors associated with lack of freshness under certain conditions. This independent packet system has an advantage over other methods of preventing deterioration due to oxygen by not becoming part of the food (i.e., they are not food additives and need not be so labeled). It may also be possible to prevent oxygen damage while using a lower barrier, and hence less expensive film. Overall cost of the food package may be reduced while increasing the acceptability and quality of the product.

Further studies should be conducted to find a practical way of avoiding the hazard of ingestion and the appearance problem discussed above. One possibility may be to adhere the packet to the interior of the package or perhaps even conceal it from view through the use of a false bottom. The more interesting possibility of incorporating the active compounds of the oxygen absorbent packet directly into the package, as are some anti-microbial agents, should be investigated.

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Table 1. Hexanal content^a in sunflower seeds stored at 65°C.

Days of Storage	High Barrier Film		Moderate Barrier Film	
	Treatment ^a	Control	Treatment ^a	Control
1	0.4	0.4	0.4	.04
2	—	—	5.8	6.6
3	4.8	4.5	—	—
6	3.1	6.7	3.5	9.4
8	—	—	4.8	8.9
9	1.9	2.3	—	—
10	—	—	6.9	12

^a µg/kg

^b packages contained **FreshPax** packet

Table 2. Sensory data (difference test) for stored peanuts

Week #	Moderate Barrier Film		High Barrier Film	
	Treatment	Control	Treatment	Control
1	10	10	7	13
2	15 ^a	5	8	12
3	16 ^b	4	3	17 ^b
4	18 ^b	2	3	17 ^b

^a significantly different at alpha—.05

^b significantly different at alpha—.01

Table 3. Category scaling summary of panelists' responses (Mean of panelists' ratings on a 9 point scale) after 7 weeks of storage (moderate barrier film) at 50°C (peanuts).

Attribute	Treatment	Control
Overall smell intensity ^a	3.94	5.34
Stale or rancid smell intensity		



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